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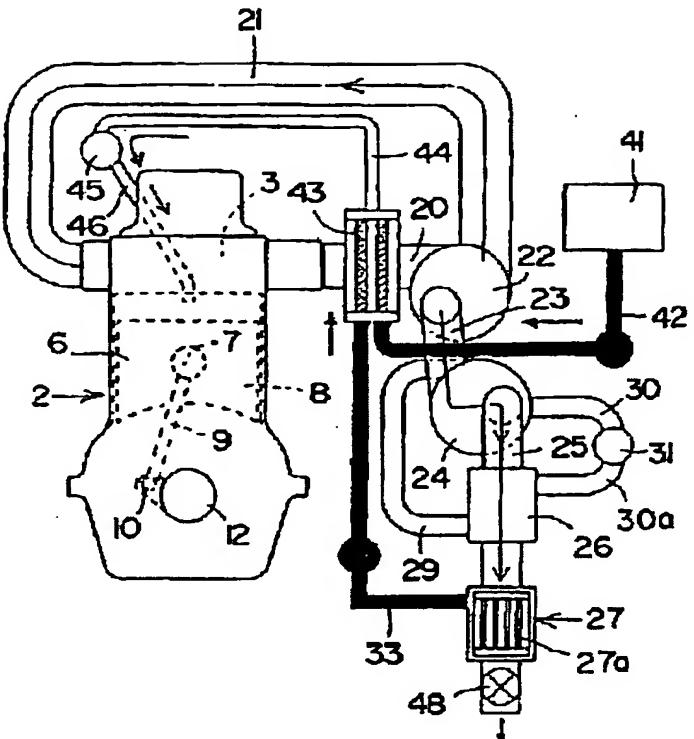
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TITLE : NATURAL GAS REFORMING
 INTERNAL COMBUSTION ENGINE



ABSTRACT : PROBLEM TO BE SOLVED: To provide a natural gas reforming internal combustion engine absorbing carbon dioxide contained in exhaust by carbon dioxide absorbent, recovering the carbon dioxide gas by heating the carbon dioxide absorbent, and using a substance formed by reacting the carbon dioxide with methane gas, or a major fuel, as the fuel.

SOLUTION: A reformer 43 is disposed in an exhaust path of an engine 2, a carbon dioxide recovery device 27 is disposed in the downstream of the reformer 43, mixed gas between the carbon dioxide from the carbon dioxide recovery device 27 with the natural gas (methane gas) is introduced to the reformer 43 via a reforming gas heat exchanger 43a, and the reformed gas reformed by the reformer 43 is fed to the engine 2 via the reformed gas heat exchanger 43a. The carbon dioxide recovery device 27 comprises a vessel 27a filled with the carbon dioxide absorbent 67, a cooler 26 cooling the exhaust to be introduced to the vessel 27a, and a heater 43b heating the carbon dioxide to be introduced to the vessel 27a by the exhaust.

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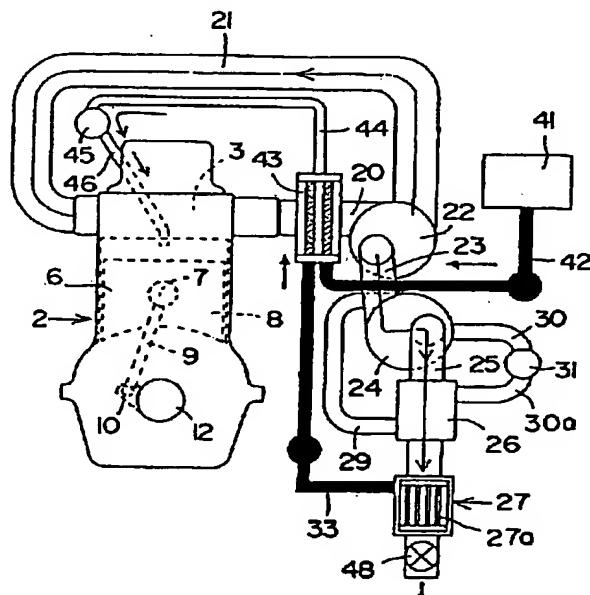
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(54) 【発明の名称】 天然ガス改質内燃機関

(57) 【要約】

【課題】 排気に含まれる炭酸ガスを炭酸ガス吸収剤により吸収し、次いで炭酸ガス吸収剤を加熱して炭酸ガスを回収し、この炭酸ガスと主燃料であるメタンガスとを反応させたものを燃料とする、天然ガス改質内燃機関を得る。

【解決手段】 機関2の排気経路に改質装置43を配設し、改質装置43の下流に炭酸ガス回収装置27を配設し、炭酸ガス回収装置27からの炭酸ガスと天然ガス(メタンガス)との混合ガスを改質ガス用熱交換器43aを経て改質装置43へ導き、改質装置43で改質された改質ガスを改質ガス用熱交換器43aを経て機関2へ供給する。炭酸ガス回収装置27は炭酸ガス吸収剤67を充填した容器27aと、容器27aへ導入する排気を冷却する冷却器26と、容器27aへ導入する炭酸ガスを排気により加熱する加熱器43bとから構成する。



【特許請求の範囲】

【請求項1】機関の排気経路に改質装置を配設し、前記改質装置の下流に炭酸ガス回収装置を配設し、前記炭酸ガス回収装置からの炭酸ガスと天然ガス(メタンガス)との混合ガスを改質ガス用熱交換器を経て前記改質装置へ導き、前記改質装置で改質された改質ガスを前記改質ガス用熱交換器を経て機関へ供給する天然ガス改質内燃機関において、前記炭酸ガス回収装置は炭酸ガス吸収剤を充填した容器と、前記容器へ導入する排気を冷却する冷却器と、前記容器へ導入する炭酸ガスを排気により加熱する加熱器とから構成されていることを特徴とする天然ガス改質内燃機関。

【請求項2】炭酸ガス吸収剤を充填した前記容器に排気の導入と炭酸ガスの排出を交互に切り換える切換弁を設けた、請求項1に記載の天然ガス改質内燃機関。

【請求項3】前記容器に充填する炭酸ガス吸収剤は、活性炭、ゼオライトなどの吸着剤と、酸化マグネシウム(MgO)、酸化カルシウム(CaO)などのアルカリ土類金属酸化物と、酸化セリウム(CeO₂)などの希土類酸化物とのいずれかである、請求項1、2に記載の天然ガス改質内燃機関。

【請求項4】前記容器は纖維、ハニカム構造体などの炭酸ガス吸収剤を保持する保持部材を具備する、請求項1～3に記載の天然ガス改質内燃機関。

【請求項5】前記改質装置に充填する触媒は、元素の周期律表の8族、1b族および／または希土類酸化物の混合物からなり、触媒の担体はセラミツクスの微粒子層を表面に有するセラミツクスの纖維および／またはハニカム構造体である、請求項1～4に記載の天然ガス改質内燃機関。

【請求項6】前記改質装置からの排気経路に蒸気タービンおよび／またはタービン発電機を配設し、前記改質装置からの排気を前記蒸気タービンまたはタービン発電機で冷却した後に炭酸ガス回収装置へ供給する、請求項1～5に記載の天然ガス改質内燃機関。

【発明の詳細な説明】

【0001】

【発明の属する技術分野】本発明はメタンを主成分とする天然ガスと排気に含まれる炭酸ガスとを反応させて熱量を高めた改質ガスを燃料とする、天然ガス改質内燃機関に関するものである。

【0002】

【従来の技術】近年、メタンを主成分とする天然ガスと炭酸ガス(CO₂)とを反応させて、発熱量の高い水素と一酸化炭素(CO)との混合ガスに改質し、燃費を向上させることが試みられている。

【0003】機関の排気から炭酸ガス(CO₂)を分離する方法として、吸着法、膜分離法、化学反応分離法などがあるが、炭酸ガス(CO₂)を分離するのに多くのエネルギーが必要なこと、分離速度が遅いなどの問題があつ

た。また、吸着法により炭酸ガス(CO₂)を回収するためには、真空ポンプを用いて炭酸ガス吸収剤が充填された容器を減圧する必要がある。また、炭酸ガス吸収剤の加熱により炭酸ガス(CO₂)を放出させて回収する場合に、発熱体から炭酸ガス吸収剤への熱伝導が良くないので、炭酸ガス吸収剤の加熱に時間がかかる。

【0004】

【発明が解決しようとする課題】本発明の課題は上述の問題に鑑み、排気に含まれる炭酸ガスを炭酸ガス吸収剤により吸収し、次いで炭酸ガス吸収剤を加熱して炭酸ガスを回収し、この炭酸ガスと主燃料であるメタンガスとを反応させたものを燃料とする、天然ガス改質内燃機関を提供することにある。

【0005】

【課題を解決するための手段】上記課題を解決するためには、本発明の構成は機関の排気経路に改質装置を配設し、前記改質装置の下流に炭酸ガス回収装置を配設し、前記炭酸ガス回収装置からの炭酸ガスと天然ガス(メタンガス)との混合ガスを改質ガス用熱交換器を経て前記改質装置へ導き、前記改質装置で改質された改質ガスを前記改質ガス用熱交換器を経て機関へ供給する天然ガス改質内燃機関において、前記炭酸ガス回収装置は炭酸ガス吸収剤を充填した容器と、前記容器へ導入する排気を冷却する冷却器と、前記容器へ導入する炭酸ガスを排気により加熱する加熱器とから構成されていることを特徴とする。

【0006】

【発明の実施の形態】本発明では炭酸ガス回収装置として、真空ポンプを使用せずに、排気の熱を利用して短時間で排気から炭酸ガスを回収する。排気熱により加熱した炭酸ガスを、炭酸ガス回収装置の炭酸ガス吸収剤へ通すことにより、炭酸ガス吸収剤を加熱して炭酸ガスを放出させる。つまり、炭酸ガス吸収剤が充填された容器へ、熱交換器により冷却された排気を通すことにより、排気に含まれる炭酸ガスを炭酸ガス吸収剤に吸収される。次いで、排気熱により加熱した炭酸ガスを、炭酸ガスを吸収した炭酸ガス吸収剤へ通すことにより、炭酸ガス吸収剤を加熱して炭酸ガスを放出させる。以上の操作を繰り返すことにより炭酸ガスを回収し、メタンガスと反応させる。

【0007】

【実施例】図1に示すように、本発明による天然ガス改質内燃機関2はシリンダ本体6にピストン8を嵌装してピストン8の上側に燃焼室3を区画され、吸気管21がシリンダ本体6の上端を開鎖するシリンダヘッドの吸気路を経て燃焼室3に接続され、また燃焼室3がシリンダヘッドの排気路を経て排気管20に接続される。シリンダヘッドの吸気路には吸気弁が、排気路には排気弁がそれぞれ配設され、カム機構により開閉されるようになつている。ピストン8には連接棒9の上端がピン7により

連結される。連接棒9の下端はクランク軸12と一体の腕にピン10により連結される。

【0008】図示の内燃機関2は火花点火式4行程内燃機関であるが、本発明は2行程内燃機関にも適用できる。燃料は燃料ポンプ45により燃料供給管46から燃焼室3へ噴射される。排気管20の途中には排気熱を利用して天然ガス（主としてメタンガス）の改質を行う改質装置43が接続される。排気管20は改質装置43を経て排気ターボ過給機22の入口へ接続される。排気ターボ過給機22の出口管23は回収ターピン24の入口へ接続される。回収ターピン24の出口管25の排気は、熱交換器26と炭酸ガス回収装置27を経て外部へ放出される。炭酸ガス回収装置27には後述する切換弁48が接続され、切換弁48の切換え操作により、容器27aの内部に収容した炭酸ガス吸収剤67に排気から炭酸ガスを吸収する工程と、炭酸ガス吸収剤67を加熱して炭酸ガスを放出させ、管33を経て改質装置43へ送る工程とを交互に行うようになっている。切換弁48は図3に6個の開閉弁48a～48fで示される。排気ターボ過給機22には好ましくは複数の空気圧縮機22aと送風機22b、22cが連結され、外部空気が空気圧縮機22aにより吸気管21を経て燃焼室3へ供給される。

【0009】燃料タンク41の天然ガスは管42を経て改質装置43へ供給され、改質装置43で天然ガスは炭酸ガスと反応して改質ガス（水素(H₂)と一酸化炭素(CO)との混合ガス）とされ、燃料ポンプ45により燃料供給管46を経て燃焼室3へ噴射される。回収ターピン24には蒸気ターピン（またはターピン発電機）が連結され、蒸気ターピンから出た蒸気は出口管30を経て凝縮器31で液化されて水となり、次いで水は管30aを経て熱交換器26で気化され、出口管25からの排気を冷却した後、管29を経て蒸気ターピンへ送られる。熱交換器26で冷却された排気は炭酸ガス回収装置27へ入り、炭酸ガス吸収剤67により排気に含まれる炭酸ガスを吸収される。炭酸ガス吸収剤67に炭酸ガスが満された時、切換弁48を切り替え、炭酸ガス吸収剤67を加熱して炭酸ガスを放出させ、管33を経て改質装置43へ送る。

【0010】図2、3に示すように、機関2からの排気は改質装置43へ送られ、熱交換器43aからのメタンガスをさらに加熱する。改質装置43から出た排気は排気ターボ過給機22、回収ターピン24、熱交換器26を経て炭酸ガス回収装置27へ送られる。燃料タンク41からの天然ガスとしてのメタン(CH₄)と、炭酸ガス回収装置27で回収した炭酸ガス(CO₂)との混合ガスを、改質ガス用熱交換器43aで加熱する。次いで、混合ガスを改質装置43へ導いて改質を行い、改質した混合ガスを改質ガス用熱交換器43aで冷却した後に、燃料として機関2へ供給する。

【0011】図3に示すように、各開閉弁48a～48fが①の状態にある時、炭酸ガス回収装置27では送風機22cにより熱交換器26へ貢流される外部空気との熱交換により排気を冷却した後に、開閉弁48fを経て炭酸ガス吸収剤67としての活性炭が充填された容器27aへ送り、排気に含まれる炭酸ガスを活性炭に吸収させる。この時、炭酸ガスを除去された排気（主として窒素ガス）は開閉弁48aを経て外部へ放出される。次いで、排気熱を熱源とする熱交換器43bにより炭酸ガスタンク27bからの炭酸ガスを加熱する。切換弁48を②の状態に切り替え、熱交換器43bで加熱した炭酸ガスを送風機22bにより容器27aへ送り、炭酸ガスを吸収した活性炭を加熱して炭酸ガスを放出させる。炭酸ガスの一部は開閉弁48aを経て炭酸ガスタンク27bへ溜め、炭酸ガスの残部は開閉弁48bを経て改質ガス用熱交換器43aへ送る。

【0012】容器27aの活性炭を温度150°Cから300°Cへ加熱するのに必要な熱量は25kW、炭酸ガスの脱着に必要な熱量は5kWであり、炭酸ガスの回収に必要な熱量は計30kWであつた。1時間当たりの炭酸ガスの回収量は12NL/sであつた。

【0013】【具体的実施例1】機関2から排出される900°Cの排気151NL/sを改質装置43へ導き、改質装置43から排出された排気を炭酸ガス回収装置27へ導いた。天然ガスとして10NL/sのメタン(CH₄)と炭酸ガス回収装置27で回収した23NL/sの炭酸ガス(CO₂)との混合ガスを改質ガス用熱交換器43aへ通した後に、改質装置43へ導くことにより改質を行い、改質したガスを燃料として機関2へ導いた。

【0014】炭酸ガス回収装置27では、熱交換器26を用いて平均流量151NL/sの排気を室温空気との熱交換により冷却し、炭酸ガス吸収剤67として活性炭が充填された容器27aへ通すことにより、排気中の炭酸ガス(CO₂)を活性炭に吸収させた。また、熱交換器43bを用いて、30kWの排気熱により炭酸ガス(CO₂)を加熱した。この時の排気の流量は151NL/sであり、温度は300°Cから150°Cに低下した。加熱した炭酸ガス(CO₂)を、炭酸ガス(CO₂)を吸収した活性炭へ通して活性炭を加熱し、活性炭から炭酸ガス(CO₂)を放出させた。活性炭を温度150°Cから300°Cへ加熱するのに必要な熱は25kW、炭酸ガス(CO₂)の脱着に必要な熱は5kW（ただし、炭酸ガスの吸着熱は10kJ/mo1）であり、炭酸ガス(CO₂)の回収に必要な熱は計30kWであつた。1時間当たりの平均炭酸ガス回収量は12NL/sであつた。天然ガスの改質率を測定したところ、改質率は8.6%、炭酸ガス回収装置27による炭酸ガス回収率は9.2%、天然ガス改質機関の熱効率は6.1%であつた。

【0015】【具体的実施例2】容器27aに充填する炭酸ガス吸収剤67として、ゼオライト、酸化マグネシ

ウム (MgO) 、酸化カルシウム (CaO) および酸化セリウム (CeO_2) を使用して試験を行つた。炭酸ガス吸収剤 67 の保持部材は使用せずに、そのまま容器 27 a へ充*

* 填して試験を行つた。その結果を下表に示す。
【0016】

CO_2 吸収剤	ゼオライト	MgO	CaO	CeO_2
回収装置の CO_2 回収率	90%	82%	80%	78%
天然ガスの改質率	85%	80%	75%	75%
機関の熱効率	55%	53%	50%	49%

[具体的実施例3] アルミナ繊維またはハニカム構造体 10※ 7 a に充填して試験を行つた。その結果を下表に示す。
を炭酸ガス吸収剤 67 の保持部材として使用し、容器 2※ 【0017】

CO_2 吸収剤	ゼオライト	MgO	CaO	CeO_2
吸収剤の保持部材	アルミナ繊維	アルミナ繊維	ハニカム構造体	ハニカム構造体
回収装置の CO_2 回収率	92%	84%	82%	80%
天然ガスの改質率	86%	82%	78%	78%
機関の熱効率	57%	54%	52%	51%

[具体的実施例4] 改質装置 4 3 に充填する触媒は、元素の周期律表の8族のルテニウム (Ru) 、白金 (Pt) 、ニッケル (Ni) の内の1つと、希土類酸化物である酸化セリウム (Ce_2O_3) との混合物を使用するか、または8族のニッケル (Ni) 、白金 (Pt) 、ルテニウム (Rh) の内の1つと、希土類酸化物である酸化セリウム (Ce_2O_3 ★

★))との混合物を使用し、触媒の担体としてアルミナの微粒子層を表面に有するアルミナ繊維および/またはハニカム構造体を使用して試験を行つた。その結果を下表に示す。

【0018】

使用した触媒	Ru-Pt-Ni	Ni-Pt-Rh	Ru-Pt-Ni	Ni-Pt-Rh
および担体	- Ce_2O_3	- Ce_2O_3	- Ce_2O_3	- Ce_2O_3
触媒の担体	アルミナ繊維	アルミナ繊維	ハニカム構造体	ハニカム構造体
回収装置の CO_2 回収率	85%	83%	82%	80%
天然ガスの改質率	84%	81%	80%	75%
機関の熱効率	61%	59%	55%	54%

【0019】

【発明の効果】本発明は上述のように、機関の排気経路に改質装置を配設し、前記改質装置の下流に炭酸ガス回収装置を配設し、前記炭酸ガス回収装置からの炭酸ガスと天然ガス (メタンガス) との混合ガスを改質ガス用熱交換器を経て前記改質装置へ導き、前記改質装置で改質された改質ガスを前記改質ガス用熱交換器を経て機関へ供給する天然ガス改質内燃機関において、前記炭酸ガス回収装置は炭酸ガス吸収剤を充填した容器と、前記容器へ導入する排気を冷却する冷却器と、前記容器へ導入する炭酸ガスを排気により加熱する加熱器とから構成したものであり、真空ポンプを使用せずに、炭酸ガス回収装置により排気熱を利用して排気から炭酸ガスを回収することができ、熱効率の高い天然ガス改質機関が得られる。

【図面の簡単な説明】

【図1】本発明に係る天然ガス改質内燃機関の概略構成

図である。

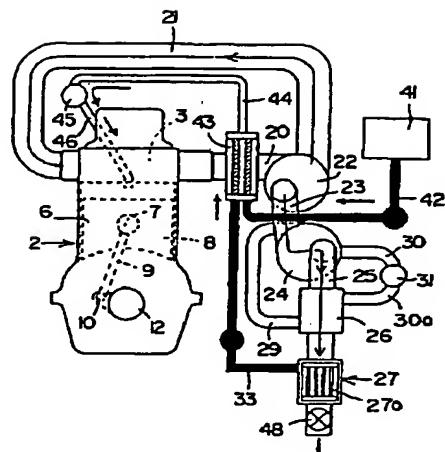
【図2】同天然ガス改質内燃機関の作用説明図である。

【図3】同天然ガス改質内燃機関の作用説明図である。

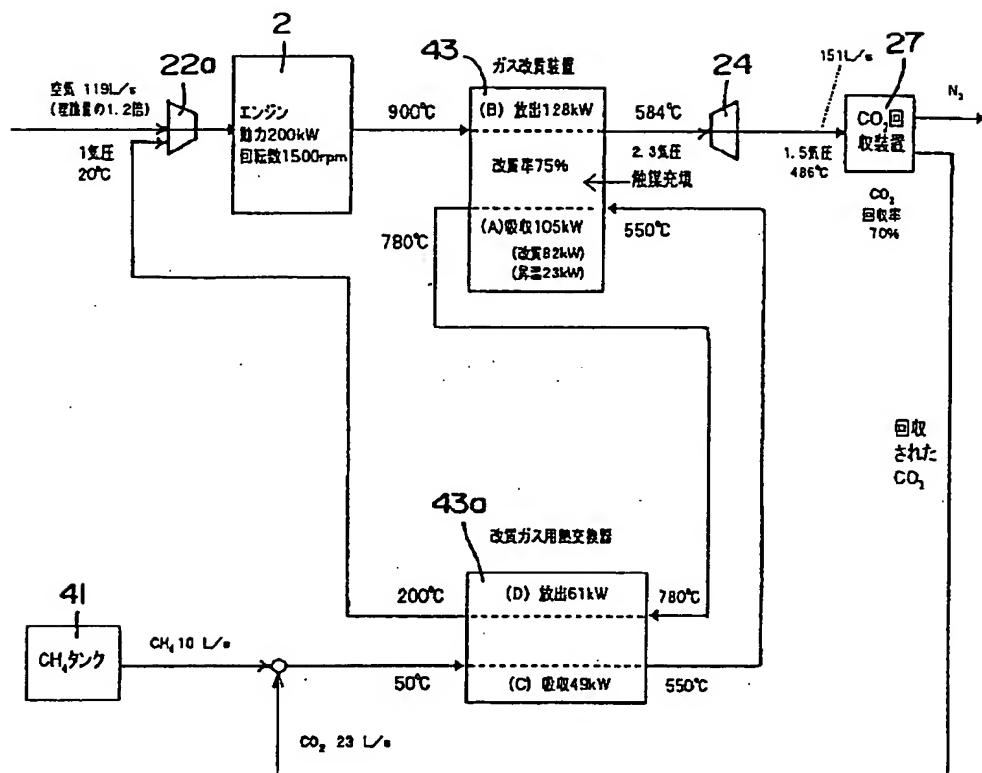
【符号の説明】

- 2 : 内燃機関 3 : 燃焼室 4 : 吸気口 5 : 排気口
 6 : シリンダ本体 8 : ピストン 9 : 連接棒 12 : クランク軸 20 : 排気管 21 : 吸気管 22 : ターボ過給機 22 a ~ 22 c : 送風機 23 : 出口管 24 : 回収ターピン
 25 : 出口管 26 : 熱交換器 (冷却器) 27 a : 容器 27 b : 炭酸ガスタンク
 31 : 凝縮器 41 : 燃料タンク 43 : 改質装置
 43 a : 熱交換器 43 b : 熱交換器 (加熱器) 45 : 燃料ポンプ
 46 : 燃料供給管 48 : 切換弁 67 : 炭酸ガス吸収剤

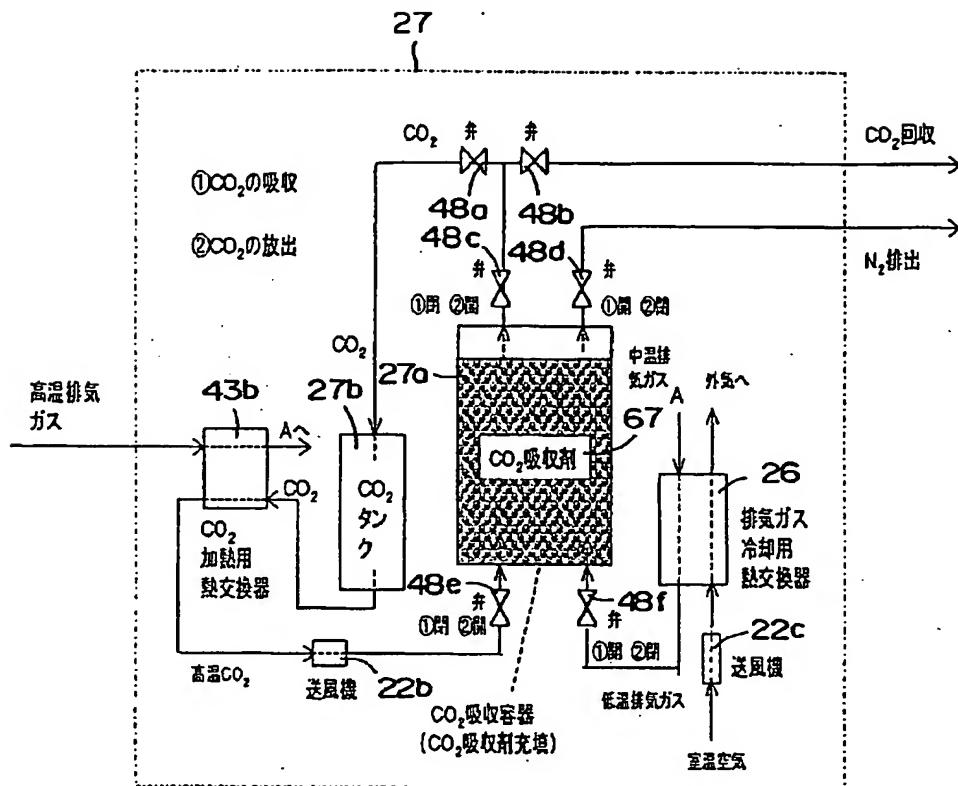
【図1】



【図2】



【図3】



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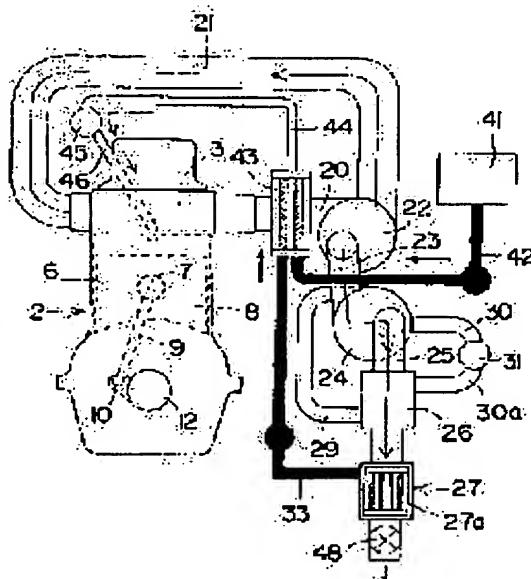
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(54) NATURAL GAS REFORMING INTERNAL COMBUSTION ENGINE

(57)Abstract:

PROBLEM TO BE SOLVED: To provide a natural gas reforming internal combustion engine absorbing carbon dioxide contained in exhaust by carbon dioxide absorbent, recovering the carbon dioxide gas by heating the carbon dioxide absorbent, and using a substance formed by reacting the carbon dioxide with methane gas, or a major fuel, as the fuel.

SOLUTION: A reformer 43 is disposed in an exhaust path of an engine 2, a carbon dioxide recovery device 27 is disposed in the downstream of the reformer 43, mixed gas between the carbon dioxide from the carbon dioxide recovery device 27 with the natural gas (methane gas) is introduced to the reformer 43 via a reforming gas heat exchanger 43a, and the reformed gas reformed by the reformer 43 is fed to the engine 2 via the reformed gas heat exchanger 43a. The carbon dioxide recovery device 27 comprises a vessel 27a filled with the carbon dioxide absorbent 67, a cooler 26 cooling the exhaust to be introduced to the vessel 27a, and a heater 43b heating the carbon dioxide to be introduced to the vessel 27a by the exhaust.



LEGAL STATUS

[Date of request for examination]

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CLAIMS

[Claim(s)]

[Claim 1] Arrange a reformer in an engine's exhaust air path, and a carbon-dioxide-gas recovery system is arranged in the lower stream of a river of said reformer. The mixed gas of the carbon dioxide gas from said carbon-dioxide-gas recovery system and natural gas (methane) is led to said reformer through the heat exchanger for reformed gas. In the natural gas reforming internal combustion engine which supplies the reformed gas by which reforming was carried out to an engine through said heat exchanger for reformed gas by said reformer Said carbon-dioxide-gas recovery system is a natural gas reforming internal combustion engine characterized by consisting of a container filled up with the carbon dioxide absorbent, a condensator which cools the exhaust air introduced to said container, and a heater which heats the carbon dioxide gas introduced to said container with exhaust air.

[Claim 2] The natural gas reforming internal combustion engine according to claim 1 which prepared the change-over valve which switches installation of exhaust air, and discharge of carbon dioxide gas to said container filled up with the carbon dioxide absorbent by turns.

[Claim 3] The carbon dioxide absorbent with which said container is filled up is a natural gas reforming internal combustion engine given in claims 1 and 2 which are either of adsorbents, such as activated carbon and a zeolite, alkaline-earth-metal oxides, such as a magnesium oxide (MgO) and a calcium oxide (CaO), and rare earth oxides, such as cerium oxide (CeO₂).

[Claim 4] Said container is a natural gas reforming internal combustion engine possessing the attachment component holding carbon dioxide absorbents, such as fiber and a honeycomb structure object, according to claim 1 to 3.

[Claim 5] He is the natural gas reforming internal combustion engine according to claim 1 to 4 which is the fiber and/or the honeycomb structure object of the ceramics with which the catalyst with which said reformer is filled up consists of mixture of eight groups of the periodic table of an element, 1b group, and/or a rare earth oxide, and the support of a catalyst has the particle layer of the ceramics on a front face.

[Claim 6] The natural gas reforming internal combustion engine according to claim 1 to 5 which supplies a carbon-dioxide-gas recovery system after arranging a steam turbine and/or a steam turbine generator in an exhaust air path from said reformer and cooling the exhaust air from said reformer with said steam turbine or steam turbine generator.

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DETAILED DESCRIPTION

[Detailed Description of the Invention]

[0001]

[Field of the Invention] This invention relates to the natural gas reforming internal combustion engine which uses as a fuel the reformed gas which the natural gas which uses methane as a principal component, and the carbon dioxide gas contained in exhaust air were made to react, and raised the heating value.

[0002]

[Description of the Prior Art] In recent years, the natural gas and carbon dioxide gas (CO₂) which use methane as a principal component are made to react, it reforms to the mixed gas of a hydrogen and a carbon monoxide (CO) with high calorific value, and to raise fuel consumption is tried.

[0003] Problems, like as an approach of separating carbon dioxide gas (CO₂) from an engine's exhaust air, although there are an adsorption process, a membrane-separation method, a chemical reaction separation method, etc., and carbon dioxide gas (CO₂) is separated, much energy's being the need and a separation rate are slow are *****. Moreover, in order to collect carbon dioxide gas (CO₂) with an adsorption process, it is necessary to decompress the container with which it filled up with the carbon dioxide absorbent using the vacuum pump. Moreover, since heat conduction from a heating element to a carbon dioxide absorbent is not good when making carbon dioxide gas (CO₂) emit with heating of a carbon dioxide absorbent and collecting, heating of a carbon dioxide absorbent takes time amount.

[0004]

[Problem(s) to be Solved by the Invention] It is in offering the natural gas reforming internal combustion engine which the technical problem of this invention absorbs the carbon dioxide gas contained in exhaust air with a carbon dioxide absorbent in view of an above-mentioned problem, and subsequently heats a carbon dioxide absorbent, collects carbon dioxide gas, and uses as a fuel the thing to which this carbon dioxide gas and the methane which is a main fuel were made to react.

[0005]

[Means for Solving the Problem] In order to solve the above-mentioned technical problem, the configuration of this invention arranges a reformer in an engine's exhaust air path. Arrange a carbon-dioxide-gas recovery system in the lower stream of a river of said reformer, and the mixed gas of the carbon dioxide gas from said carbon-dioxide-gas recovery system and natural gas (methane) is led to said reformer through the heat exchanger for reformed gas. In the natural gas reforming internal combustion engine which supplies the reformed gas by which reforming was carried out to an engine through said heat exchanger for reformed gas by said reformer It is characterized by said carbon-dioxide-gas recovery system consisting of a container filled up with the carbon dioxide absorbent, a condensator which cools the exhaust air introduced to said container, and a heater which heats the carbon dioxide gas introduced to said container with exhaust air.

[0006]

[Embodiment of the Invention] In this invention, carbon dioxide gas is collected from exhaust air as a carbon-dioxide-gas recovery system for a short time using the heat of exhaust air, without using a vacuum pump. A carbon dioxide absorbent is heated and carbon dioxide gas is made to emit by letting the carbon dioxide gas heated with exhaust air heat pass to the carbon dioxide absorbent of a carbon-dioxide-gas recovery system. That is, a carbon dioxide absorbent is made to absorb the carbon dioxide gas contained in exhaust air by letting the exhaust air cooled by the heat exchanger pass to the container with which it filled up with the carbon dioxide absorbent. Subsequently, a carbon dioxide absorbent is heated and carbon dioxide gas is made to emit by letting

the carbon dioxide gas heated with exhaust air heat pass to the carbon dioxide absorbent which absorbed carbon dioxide gas. Carbon dioxide gas is collected and it is made to react with methane by repeating the above actuation.

[0007]

[Example] As shown in drawing 1, it connects with a combustion chamber 3 through the inhalation-of-air way of the cylinder head where the natural gas reforming internal combustion engine 2 by this invention fits a piston 8 in a cylinder body 6 on, and has a combustion chamber 3 divided by the piston 8 bottom on, and an inlet pipe 21 closes the upper limit of a cylinder body 6, and a combustion chamber 3 is connected to an exhaust pipe 20 through the exhaust air way of the cylinder head. Intermediary **** [as] which an inlet valve is arranged in the inhalation-of-air way of the cylinder head, and an exhaust valve is arranged in an exhaust air way, respectively, and is opened and closed by the cam mechanism. The upper limit of a connecting rod 9 is connected with a piston 8 by the pin 7. The lower limit of a connecting rod 9 is connected with the arm of a crankshaft 12 and one by the pin 10.

[0008] Although the internal combustion engine 2 of illustration is an internal combustion engine the jump-spark-ignition type of about four lines, this invention of about two lines is applicable also to an internal combustion engine. A fuel is injected from a fuel feeding pipe 46 by the fuel pump 45 to a combustion chamber 3. The reformer 43 which performs reforming of natural gas (mainly methane) using exhaust air heat is connected in the middle of an exhaust pipe 20. An exhaust pipe 20 is connected to the inlet port of the exhaust air turbosupercharger 22 through a reformer 43. The outlet pipe 23 of the exhaust air turbosupercharger 22 is connected to the inlet port of the recovery turbine 24. Exhaust air of the outlet pipe 25 of the recovery turbine 24 is emitted to the exterior through a heat exchanger 26 and the carbon-dioxide-gas recovery system 27.

Intermediary **** [as] which the change-over valve 48 mentioned later is connected to the carbon-dioxide-gas recovery system 27, and performs by turns the process which absorbs carbon dioxide gas from exhaust air to the carbon dioxide absorbent 67 held in the interior of container 27a, and the process which heats a carbon dioxide absorbent 67, is made to emit carbon dioxide gas, and is sent to a reformer 43 through tubing 33 by change actuation of a change-over valve 48. A change-over valve 48 is shown to drawing 3 by six closing motion valves 48a-48f. Two or more desirable air compressor 22a and Blowers 22b and 22c are connected with the exhaust air turbosupercharger 22, and exterior air is supplied to a combustion chamber 3 by air compressor 22a through an inlet pipe 21.

[0009] The natural gas of a fuel tank 41 is supplied to a reformer 43 through tubing 42, and natural gas reacts with carbon dioxide gas by the reformer 43, and it considers as reformed gas (mixed gas of hydrogen (H₂) and a carbon monoxide (CO)), and is injected through a fuel feeding pipe 46 to a combustion chamber 3 by the fuel pump 45. A steam turbine (or steam turbine generator) is connected with the recovery turbine 24, it is liquefied with a condenser 31 through an outlet pipe 30, and the steam which came out of the steam turbine serves as water, and subsequently, after water is evaporated by the heat exchanger 26 through tubing 30a and cools the exhaust air from an outlet pipe 25, it is sent to a steam turbine through tubing 29. The exhaust air cooled by the heat exchanger 26 goes into carbon dioxide scrubber 27, and has carbon dioxide gas contained in exhaust air with a carbon dioxide absorbent 67 absorbed. When carbon dioxide gas is filled by the carbon dioxide absorbent 67, switch a change-over valve 48, and heat a carbon dioxide absorbent 67, carbon dioxide gas is made to emit, and it sends to a reformer 43 through tubing 33.

[0010] As shown in drawing 2 and 3, the exhaust air from an engine 2 is sent to a reformer 43, and heats the methane from heat exchanger 43a further. The exhaust air which came out of the reformer 43 is sent to the carbon-dioxide-gas recovery system 27 through the exhaust air turbosupercharger 22, the recovery turbine 24, and a heat exchanger 26. The methane (CH₄) as natural gas from a fuel tank 41 and mixed gas with the carbon dioxide gas (CO₂) collected with the carbon-dioxide-gas recovery system 27 are heated by heat exchanger 43a for reformed gas. Subsequently, mixed gas is led to a reformer 43, and after cooling the mixed gas which reformed by performing reforming by heat exchanger 43a for reformed gas, an engine 2 is supplied as a fuel.

[0011] Activated carbon is made to absorb the carbon dioxide gas contained in delivery and exhaust air to container with which it filled up with activated carbon as carbon dioxide absorbent 67 through 48f of closing motion valves after cooling exhaust air by heat exchange with exterior air which flows through to heat exchanger 26 by blower 22c in carbon-dioxide-gas recovery system 27 when each closing motion valves [48]-48f are in condition of **, as [shown in drawing 3], and 27a. At this time, the exhaust air (mainly

nitrogen gas) removed in carbon dioxide gas is emitted to the exterior through closing motion valve 48a. Subsequently, the carbon dioxide gas from carbonic acid gas holder 27b is heated by heat exchanger 43b which makes exhaust air heat a heat source. A change-over valve 48 is switched to the condition of **, the activated carbon which absorbed delivery and carbon dioxide gas for the carbon dioxide gas heated by heat exchanger 43b to container 27a by blower 22b is heated, and carbon dioxide gas is made to emit. A part of carbon dioxide gas is accumulated to carbonic acid gas holder 27b through closing motion valve 48a, and the remainder of carbon dioxide gas is sent to heat exchanger 43a for reformed gas through closing motion valve 48b.

[0012] The heating value which needs a heating value required to heat the activated carbon of container 27a from the temperature of 150 degrees C to 300 degrees C for the desorption of 25kW and carbon dioxide gas is 5kW, a heating value required for recovery of carbon dioxide gas is 30kW in total, and it is *****. The amount of recovery of the carbon dioxide gas per hour is 12 NL/s, and is *****.

[0013] 900-degree C exhaust air 151 NL/s discharged by the [concrete example 1] engine 2 was led to the reformer 43, and the exhaust air discharged from the reformer 43 was led to the carbon-dioxide-gas recovery system 27. After letting the mixed gas of the methane (CH₄) of 10 NL/s, and the carbon dioxide gas (CO₂) of 23 NL/s collected with the carbon-dioxide-gas recovery system 27 pass to heat exchanger 43a for reformed gas as natural gas, by leading to a reformer 43, reforming was performed and it led to the engine 2 by using the reformed gas as a fuel.

[0014] Activated carbon was made to absorb the carbon dioxide gas under exhaust air (CO₂) in the carbon-dioxide-gas recovery system 27 by cooling exhaust air of average stream flow 151 NL/s by heat exchange with room temperature air using a heat exchanger 26, and letting it pass to container 27a with which activated carbon was filled up as a carbon dioxide absorbent 67. Moreover, carbon dioxide gas (CO₂) was heated with 30kW exhaust air heat using heat exchanger 43b. The flow rate of the exhaust air at this time is 151 NL/s, and temperature fell to 150 degrees C from 300 degrees C. It let the heated carbon dioxide gas (CO₂) pass to the activated carbon which absorbed carbon dioxide gas (CO₂), activated carbon was heated, and carbon dioxide gas (CO₂) was made to emit from activated carbon. The heat which heat required to heat activated carbon from the temperature of 150 degrees C to 300 degrees C needs for the desorption of 25kW and carbon dioxide gas (CO₂) is 5kW (however, the heat of adsorption of carbon dioxide gas 10 kJ/mol), heat required for recovery of carbon dioxide gas (CO₂) is 30kW in total, and it is *****. The amount of average carbon-dioxide-gas recovery per hour is 12 NL/s, and is *****. The carbon-dioxide-gas recovery according [the rate of reforming] to 86% and the carbon-dioxide-gas recovery system 27 when the rate of reforming of natural gas was measured is 61%, and the thermal efficiency of 92% and a natural gas reforming engine is *****.

[0015] As a carbon dioxide absorbent 67 with which [concrete example 2] container 27a is filled up, a zeolite, a magnesium oxide (MgO), a calcium oxide (CaO), and cerium oxide (CeO₂) are used, and it is ***** about a trial. Without using it, the attachment component of a carbon dioxide absorbent 67 carries out container 27a HE restoration as it is, and is ***** about a trial. The result is shown in the following table.

[0016]

----- CO₂ absorbent Zeolite MgO CaO CeO₂ CO₂ recovery of a recovery system 90% 82% 80% 78% The rate of reforming of natural gas 85% 80% 75% 75% An engine's thermal efficiency 55% 53% 50% A 49% ----- [concrete example 3] alumina fiber or a honeycomb structure object is used as an attachment component of a carbon dioxide absorbent 67, container 27a is filled up, and it is ***** about a trial. The result is shown in the following table.

[0017]

----- CO₂ absorbent Zeolite MgO CaO CeO₂ The attachment component of an absorbent Alumina fiber Alumina fiber Honeycomb structure object Honeycomb structure object CO₂ recovery of a recovery system 92% 84% 82% 80% The rate of reforming of natural gas 86% 82% 78% 78% An engine's thermal efficiency 57% 54% 52% 51% ----- The catalyst with which the [concrete example 4] reformer 43 is filled up One of the ruthenium (Ru) of eight groups of the periodic table of an element, platinum (Pt), and nickel (nickel) Using mixture with the cerium oxide (Ce₂O₃) which is a rare earth oxide Or one of eight groups' nickel (nickel), platinum (Pt), and rutheniums (Rh) Mixture with the cerium oxide (Ce₂O₃) which is a rare earth oxide is used, the alumina fiber and/or honeycomb structure object which have the particle layer of an alumina on a front face as support of a catalyst are used, and it is ***** about a trial. The result is shown in the following table.

[0018]

The used catalyst Ru-Pt-nickel nickel-Pt-Rh Ru-Pt-nickel nickel-Pt-Rh And support - Ce 2O₃ - Ce 2O₃ - Ce 2O₃ - Ce 2O₃ Support of a catalyst Alumina fiber Alumina fiber Honeycomb structure object Honeycomb structure object CO₂ recovery of a recovery system 85% 83% 82% 80% The rate of reforming of natural gas 84% 81% 80% 75% An engine's thermal efficiency 61% 59% 55% 54%

[0019]

[Effect of the Invention] As mentioned above, this invention arranges a reformer in an engine's exhaust air path, and arranges a carbon-dioxide-gas recovery system in the lower stream of a river of said reformer. The mixed gas of the carbon dioxide gas from said carbon-dioxide-gas recovery system and natural gas (methane) is led to said reformer through the heat exchanger for reformed gas. In the natural gas reforming internal combustion engine which supplies the reformed gas by which reforming was carried out to an engine through said heat exchanger for reformed gas by said reformer The container with which said carbon-dioxide-gas recovery system was filled up with the carbon dioxide absorbent, and the condensator which cools the exhaust air which introduces to said container, It can constitute from a heater which heats the carbon dioxide gas introduced to said container with exhaust air, a carbon-dioxide-gas recovery system can recover carbon dioxide gas from exhaust air using exhaust air heat, without using a vacuum pump, and a natural gas reforming engine with high thermal efficiency is obtained.

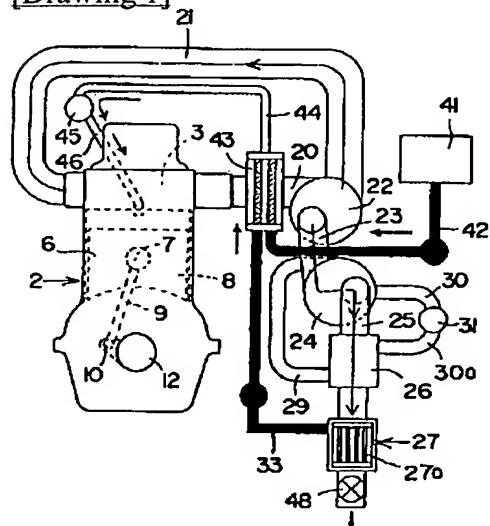
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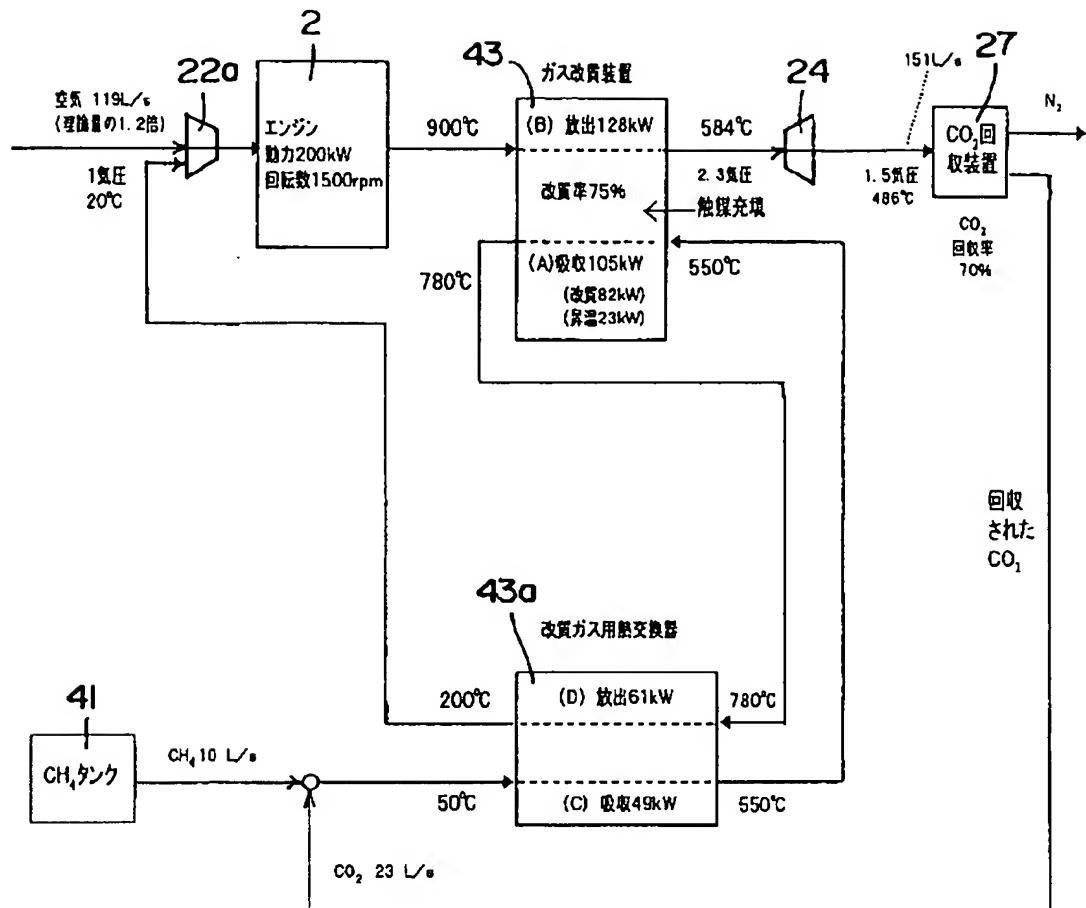
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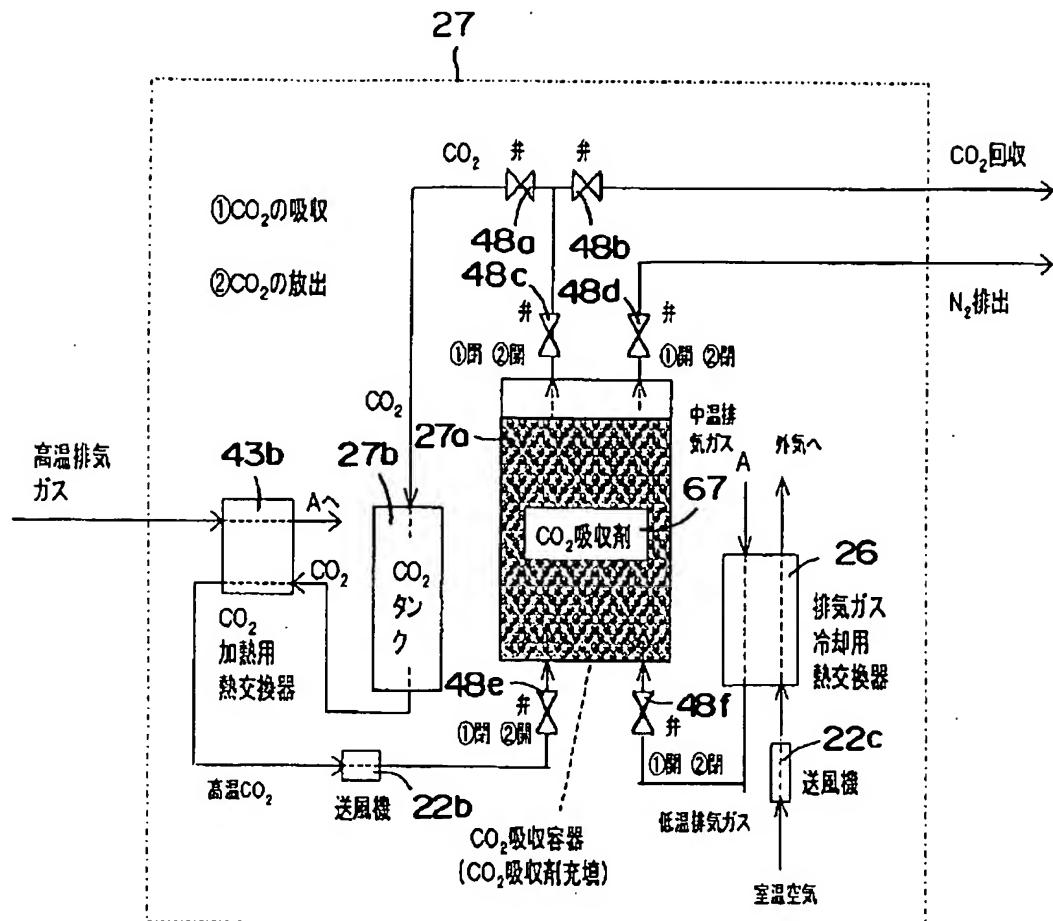
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DRAWINGS

[Drawing 1]**[Drawing 2]**



[Drawing 3]



[Translation done.]